Rising Waters

Climate Change Impacts and Toxic Risks to Lake Michigan's Shoreline Communities

ENVIRONMENTAL LAW & POLICY CENTER

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Introduction

Climate change is causing more extreme Lake Michigan water levels. High water levels, combined with stronger winds and heavier storms, are causing erosion, beach loss, and damage to residential, commercial, and industrial areas all along the shore. Many sites have toxic materials that pose risks to communities and the lake—risks that need to be understood and viewed in the context of a changing climate.

The Environmental Law & Policy Center (ELPC) identified twelve areas along Lake Michigan that face flooding and erosion risks, including residential communities, industrial facilities with hazardous materials, and a nuclear waste site. Using elevation data prepared by the National Oceanic and Atmospheric Administration (NOAA)'s Office for Coastal Management, we created twelve maps that visualize the possible extent and severity of inundation in these areas due to storm-related flooding events during high lake levels.[1] These maps extend lake level estimates beyond NOAA's upper range of 584.8 feet above sea level to envision more extreme conditions by four half-meter intervals from 584 feet up to 589 feet. We recognize that many more communities around the lake face threats from high lake levels and extreme weather events, but these twelve sites stood out in our analysis. They should be reevaluated to prepare for the new risks caused by climate change.

This report seeks to inform Lake Michigan communities about the risks in their backyards. We also identify federal, state, and local opportunities to alleviate climate change threats and protect against flooding-induced industrial pollution and damage to the built environment.

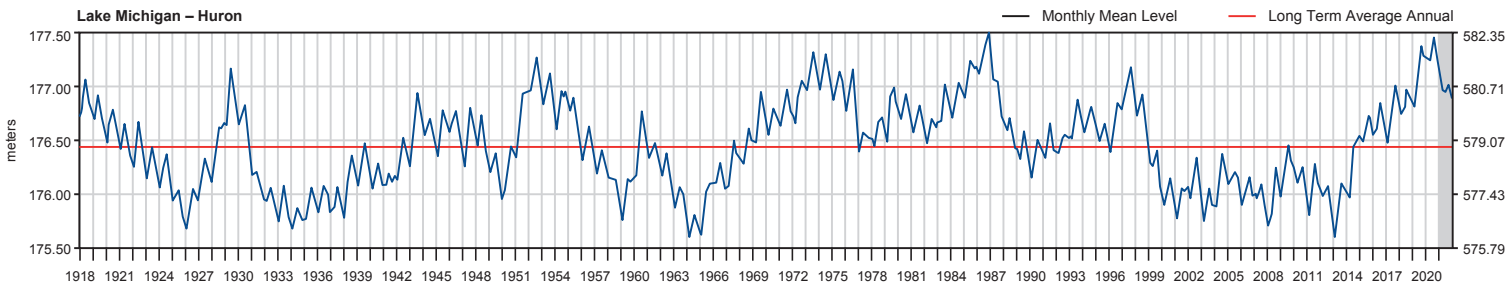
CLIMATE CHANGE IMPACTS ON LAKE MICHIGAN

Over the past decade, Lake Michigan water levels have reached new extremes, shifting from a record low monthly average of 576 feet in 2013 to a near-record high of 582.2 feet in 2020.[2] This unprecedented six-foot swing in lake levels within such a short period is largely driven by climate change. While scientists expect global mean sea levels to rise somewhat consistently, the Great Lakes are expected to both rise and fall, fueled by an accelerating "tug of war" between numerous factors.[3] In some years, higher temperatures and lower ice levels can increase evaporation and cause low lake levels. In other years, broad ice cover and high levels of precipitation can cause extremely high lake levels.

For every 1°C of warming, the atmosphere can hold 7% more water vapor, which becomes precipitation.[4] The Midwest has already experienced a 1.5°F rise in annual mean temperatures and an almost 10% increase in annual precipitation over the past century, with about 35% more rainfall on the four wettest days of the year.[5] More frequent and intense rain and snowstorms contribute to greater flooding, especially in combination with high lake levels. Scientists expect these trends to continue. While lake levels have always fluctuated, these new extremes stress our infrastructure beyond its capacity, causing devastating damage that is costly to repair.

Wave energy also increases with higher water levels, compounding the risk of flooding.[6] Winter wave heights can already exceed 8 feet and the increased risk of flooding and shoreline erosion is especially dangerous because of nearby industrial facilities and

U.S. Army Corps Historical Lake Michigan Water Level Data (1918 – 2021)



contaminated sites.[7] If a severe storm hits during a high-water period, it could breach facility barriers and carry industrial pollutants to surrounding areas and into Lake Michigan.

AREAS OF RISK

The twelve maps in this report identify hotspots in four states: Wisconsin, Illinois, Indiana, and Michigan. We prioritized areas where existing facilities are significant sources of pollution into Lake Michigan, areas where flooding could significantly impact local residences and businesses, and areas where local environmental advocacy and community groups have already raised concerns.

The maps show inundation estimates at water levels of 584–589 feet. The base level of 584 feet is 1.77 feet above the all-time high month-long average for Lake Michigan-Huron set in October 1986, so these assessments should be considered risks arising from a combination of high lake levels and extreme storm events. Water levels were estimated using an "enhanced bathtub model" (Williams and Lück-Vogel 2020). This GIS-based method maintains hydrological connectivity and incorporates beach slope and surface roughness to estimate inundation extent and severity during storm-related coastal flooding events.

In the case of permitted facilities, we detail the nature of operations, the pollutants that may be stored onsite, and the facility's history, if any, of violating environmental laws. The highlighted facilities include wastewater treatment, coal power generation, scrap metal recycling, steelmaking and finishing, aerospace coating, and nuclear power generation. Some are still operational, while others have shuttered but may still have remaining contaminants on-site.

We also provide geographic and demographic information for each hotspot, including vulnerable environmental justice communities that, as the Illinois legislature stated in the Illinois Environmental Justice Act, "suffer disproportionately from environmental hazards relating to" industrial facilities.[8] For example, in the East Side neighborhood on Chicago's Southeast Side, which ranks in at least the 80th percentile for each of the ten primary environmental justice indices, we identify three facilities within just two miles of each other. In Waukegan, there are four Superfund sites, an old coal plant, and a manufacturing plant located within approximately two square miles.

The maps in this report are not a substitute for higher resolution, site-specific, hydrodynamic analysis. The Federal Emergency Management Agency (FEMA) is currently conducting this type of analysis in an effort to update Flood Rate Insurance Maps in the Great Lakes region, and the Army Corps of Engineers will begin a new Chicago-area analysis soon as well. ELPC's analysis focuses on the immediate area surrounding southern Lake Michigan, and does not fully account for nearby flooded rivers, groundwater, or wastewater systems, which would likely rise alongside lake levels. This is not a full examination of at-risk communities, since flooding, erosion, and other climate change impacts pose threats to many areas around Lake Michigan. Nonetheless, this analysis provides a useful starting point. This report should be used for initial risk assessment, spreading awareness of potential impacts, and prioritizing management actions.

MAPS

WISCONSIN

Wisconsin has over a thousand miles of Great Lakes shoreline, making it particularly vulnerable to extreme water levels.[9] Many of the state's largest cities hug the western shores of Lake Michigan, from Milwaukee in the south to Green Bay in the north. Flooding and erosion have already affected several communities along the shoreline, but polluting facilities pose additional risks.

Manitowoc and Two Rivers

The northernmost hotspot in our report, Two Rivers, is home to 11,300 people, about halfway between Milwaukee and the tip of Door County.[10] The neighboring larger city of Manitowoc lies about ten miles south, with a population of 34,500 people.[11]

Both Manitowoc and Two Rivers were built right up to Lake Michigan to take advantage of the Great Lakes shipping industry. Major flooding events threaten residential and industrial facilities located along the shoreline and along the major rivers in these cities. The wastewater treatment plants in both cities are exposed to storm surges and wave action in Lake Michigan. These plants are already contributors to compromised water quality in the area. Each has a history of discharging effluents, including total suspended solids, phosphorus, nitrogen/ammonia, E. coli, fecal coliforms, and mercury, in violation of their permits. An extreme weather event during high lake level periods could trigger overflows and damage exposed infrastructure on the lake's shoreline.

High water levels pose risks to several facilities in Wisconsin, including two wastewater treatment plants and a coal plant with unlined coal ash ponds located right near the Lake Michigan shore.

Sheboygan

Sheboygan has 50,000 residents around the mouth of the Sheboygan River on Lake Michigan, about thirty miles south of Manitowoc and sixty miles north of Milwaukee.[12] Sheboygan's extensive shoreline is at risk of flooding and steady coastal erosion, particularly its public beaches and lakeside homes. The city's coal plant, located about three miles south of downtown Sheboygan, is particularly concerning.

The Alliant Edgewater Generating Station contains open-air coal-ash ponds and a coal ash landfill. Outfalls from the plant discharge copper, arsenic, and mercury into the nearby Black River, which carries them into Lake Michigan. High lake water levels could also flood the Black River and spill toxic materials from the coal ash ponds into these waterways.

Two Rivers Wastewater Treatment Plant

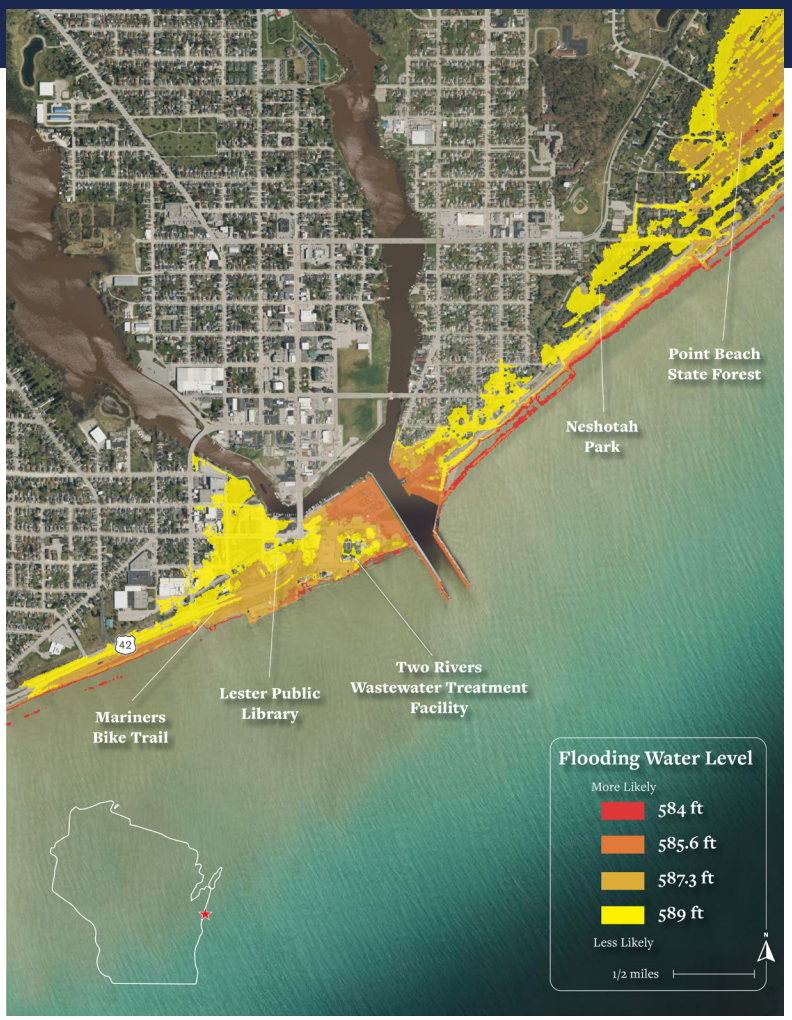
1415 Lake Street, Two Rivers, Wisconsin

The Two Rivers Wastewater Treatment Plant sits in a low-lying area surrounded by Lake Michigan and the Two Rivers Harbor, making it vulnerable to flooding and extreme weather. If water levels reach 587.3 feet above sea level, the facility would be almost surrounded by water, increasing the risks of erosion and sewage contamination. On-site pollutants such as fecal coliforms, nitrogen, and mercury could threaten the lake and surrounding communities.

The plant handles approximately 3.07 million gallons of sewage per day, and it discharges treated water into the Two Rivers Harbor on its eastern border under two Clean Water Act permits.[13] The property includes several clarifier tanks and aeration basins where sewage is designed to go through many stages of treatment before being released as effluent water. High lake levels and extreme weather could cause overflows and wash out these primary/secondary clarifiers, aeration tanks, and other exposed infrastructure. Additionally, flooding could damage machinery and electrical systems at this facility, further harming its ability to process sewage.

From May 2019 through August 2021, the plant intermittently failed to submit monthly effluent reports for various pollutants/substances, including total suspended solids, phosphorus, nitrogen/ammonia, E. coli, fecal coliforms, and mercury.[14] Suspended solids and fecal coliforms indicate overall water quality, whereas phosphorous and nitrogen can lead to harmful algal blooms.[15] Exposure to E. coli, a pathogen, or mercury, a neurotoxin, may harm human health.[16]

According to the EPA, 12,201 people live within a three-mile radius of the wastewater treatment plant—28% of the population lives below the poverty level, and 7% of the population is racially or ethnically marginalized.[17] In addition to concerns about the wastewater treatment plant, high water and extreme



weather could also affect community infrastructure including homes and businesses, the city library, the lakefront bike path, and Route 42 Memorial Drive. North of the city, floodwater could inundate Neshotah Park and Point Beach State Forest.

Two Rivers' separated sewage system helps to protect the city in some ways by preventing the combined sewer overflows fueled by heavy storms that are common in many Great Lakes communities. However, the city's central wastewater facility still poses a risk, especially considering its spotty record of Clean Water Act compliance. Local leaders should ensure that this plant is fully prepared for extreme flooding events, in light of changing Lake Michigan water levels.

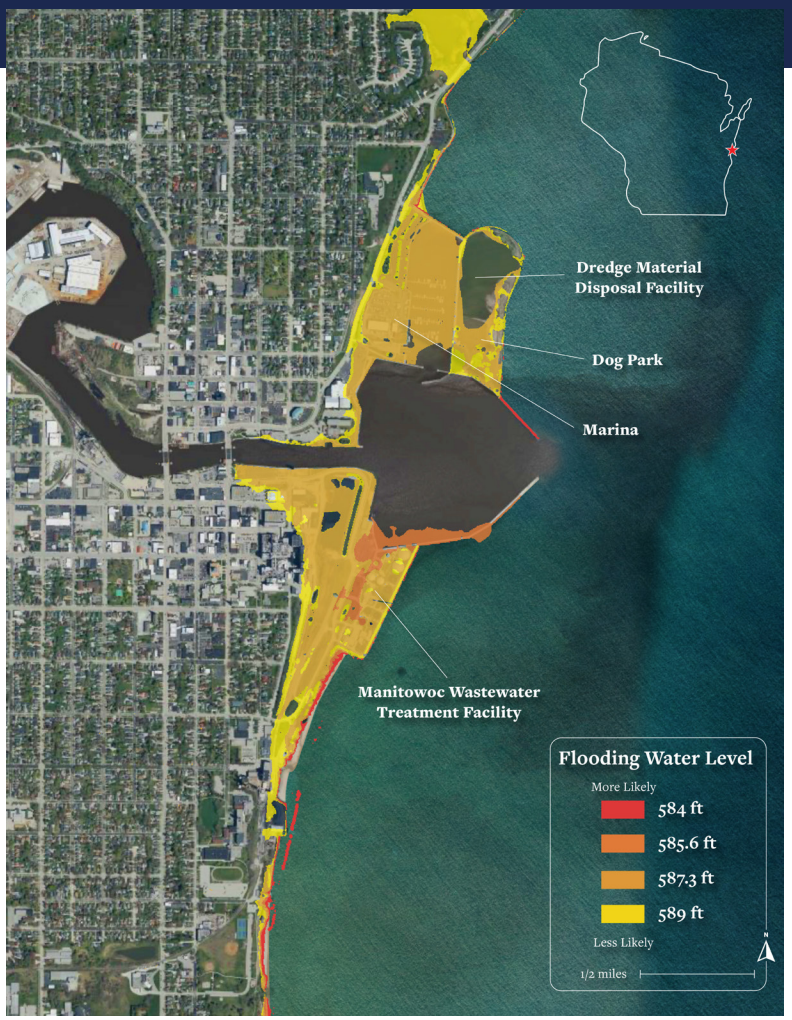
Manitowoc Wastewater Treatment Plant

1015 South Lakeview Drive, Manitowoc, Wisconsin

The Manitowoc Wastewater Treatment Plant is located on the shore of Lake Michigan, which puts it at risk of high lake levels and extreme weather. If water levels reach 585.6 feet above sea level, a large section of the facility could be inundated, and at 587.3 feet, the plant could be surrounded. This facility already has a concerning record of wastewater permit violations; extreme lake conditions could increase the risk of erosion and sewage contamination, including chlorine and fecal coliform bacteria.

The plant handles 15.5 million gallons of sewage per day and sends biosolids to nearby agricultural lands for reuse.[18] It discharges treated water into Lake Michigan under a Clean Water Act permit and a Resources Conservation and Recovery Act (RCRA) permit. The property includes several clarifier tanks and aeration basins where sewage is designed to go through many stages of treatment before being released as effluent water. High lake levels and extreme weather could cause overflows and wash out these primary/secondary clarifiers, aeration tanks, and other exposed infrastructure. Additionally, flooding could damage machinery and electrical systems at this facility, further harming its ability to process sewage.

Over the past few years, the Manitowoc Wastewater Treatment Plant has polluted several times. In 2018, the plant reported levels of chlorine at 495% and 161% above U.S. EPA limits and fecal coliform levels at 327% and 450%.[19] Chlorine is toxic to fish and freshwater invertebrates at high levels and may pose a risk to endangered aquatic species.[20] Fecal coliform, which usually arises from sewer or septic waste, indicates the presence of disease-causing bacteria, such as those that cause typhoid, dysentery, hepatitis A, and cholera.[21]



According to the U.S. EPA, 29,764 people live within a three-mile radius of the facility—35% of the population lives below the poverty level, and 15% of the population is racially or ethnically marginalized.[22] In addition to concerns about the wastewater treatment plant, high water and extreme weather could also affect community infrastructure. Some homes and businesses could flood, in addition to US Highway 10, the city dog park, marina, and dredge material disposal facility. This plant has shown significant problems managing its discharges under current lake levels. In light of changing Lake Michigan water levels, the plant operators should reassess their plans and capacity for withstanding more extreme flooding events.[23]

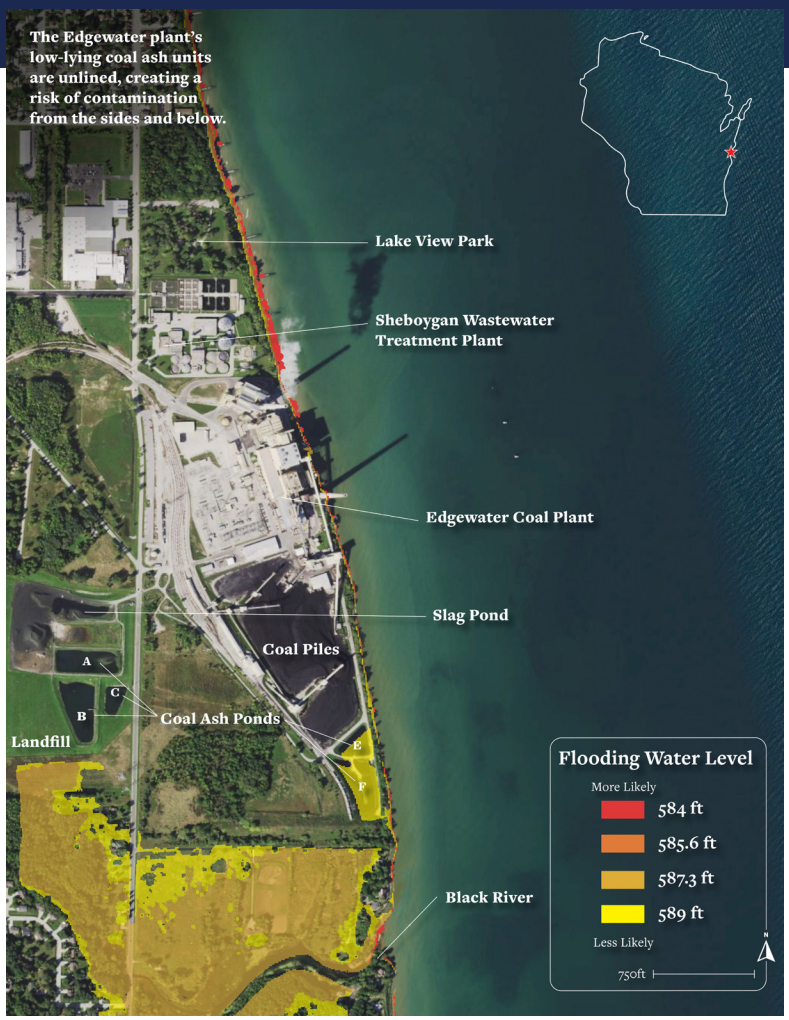
Alliant Edgewater Coal Plant

3739 Lakeshore Drive, Sheboygan, Wisconsin

Alliant Energy's Edgewater Coal Plant sits on the shore of Lake Michigan just south of Sheboygan's city center. While the flood risk for this facility is not immediately clear on the map, because the northern part of the property is on a bluff, there are significant concerns in the low-lying areas to the south.[24] Directly next to the lake, the retaining walls for coal ash ponds E and F could be vulnerable to erosion under extreme weather conditions, and if water levels reach 589 feet above sea level, these coal ash ponds could flood and potentially contaminate the lake.

Alliant plans to fully retire this coal plant by the end of 2022 as part of a transition to renewable energy. The facility discharges into Lake Michigan at six locations under a Clean Water Act permit.[25] The site also houses multiple unlined coal ash disposal areas, including four slag ponds and one coal combustion residuals landfill.[26] According to the EPA, nearly all of the ponds have been poorly maintained.[27] The coal plant also discharges stormwater and effluents from a fuel tank area into a roadside ditch which joins the Black River. If water levels reached 587.3 feet, the Black River could flood far beyond its banks, washing out this ditch and nearly reaching two inland coal ash ponds.

According to the U.S. EPA's Toxic Release Inventory, the Edgewater coal plant discharged or output the following toxins in 2020: ammonia, barium, benzo[ghi]perylene, hydrogen fluoride, lead, mercury, naphthalene, polycyclic aromatics, sulfuric acid, and vanadium.[28] Water quality sampling performed at the site also indicates the need for effluent limitations for copper, arsenic, and mercury.[29] 28,744 people live within a three-mile radius of the facility, 34% of the population lives below the poverty level, and 22% of the population is racially or ethnically marginalized.[30]



Given the many pollutants on the site, Alliant Energy should reexamine the structural integrity of its coal ash ponds to ensure that Lake Michigan water is protected, even in extreme circumstances.[31]

MAPS

ILLINOIS

Illinois' 63 miles of Lake Michigan shoreline is densely populated and interspersed with industrial areas, so extreme lake levels present serious challenges for the prairie state.[32]

A major storm surge, combined with high lake levels, could simultaneously flood streets, homes, and businesses from Zion to the Southeast Side of Chicago. Several communities have already been dealing with flooding and erosion due to heavy storms. A major flood could also threaten public health by carrying contaminants, such as PCBs and heavy metals, into populous urban neighborhoods.

Illinois poses the greatest risks of the four states in this report. High water could impact a nuclear waste site, a coal plant, a dredge dump, several superfund sites, and densely populated communities.

Zion and Waukegan

Near the Wisconsin border, Zion has 24,500 residents and is also the site of the shuttered Zion Nuclear Power Plant, which contains highly radioactive spent nuclear fuel rods encased in concrete cannisters.[33] The site is surrounded by Illinois Beach State Park's shoreline beaches and sensitive ecosystem, which have suffered from coastal erosion, exacerbated by intensified waves and storm surges.[34]

The working-class city of Waukegan has 90,000 residents just south of Zion and 40 miles north of downtown Chicago. Clustered along Waukegan's lakefront are an old coal plant, a water filtration plant, and several Superfund sites that are at risk of flooding under high water conditions and extreme weather.

Chicago

Chicago is home to 2.7 million people and enjoys 22 miles of Lake Michigan shoreline.[35] On Chicago's North Side, in the dense Rogers Park, Edgewater, and Uptown communities, extreme lake levels and flooding could cause widespread damage to homes and businesses as far as half a mile inland from the lakefront. The city's central lakeshore is dominated by large parks, beaches, and transportation infrastructure. High water has already caused considerable damage to DuSable Lakeshore Drive and the Lakefront Trail in recent years. This whole corridor is at risk of damage, but we highlighted two areas in particular: near Belmont Harbor in Lakeview and 57th street in Hyde Park.

In the event of high lake levels and extreme weather conditions, much of the South Shore neighborhood is likewise at risk of flooding, affecting homes and businesses more than half a mile from the lakeshore. Further south, the East Side neighborhood near the Calumet River has multiple industrial facilities at risk of flooding and contamination, including a confined disposal facility, which contains toxic dredging wastes, a shipping yard, and a shuttered metal shredding plant.

Zion Nuclear Spent Fuel Storage Site

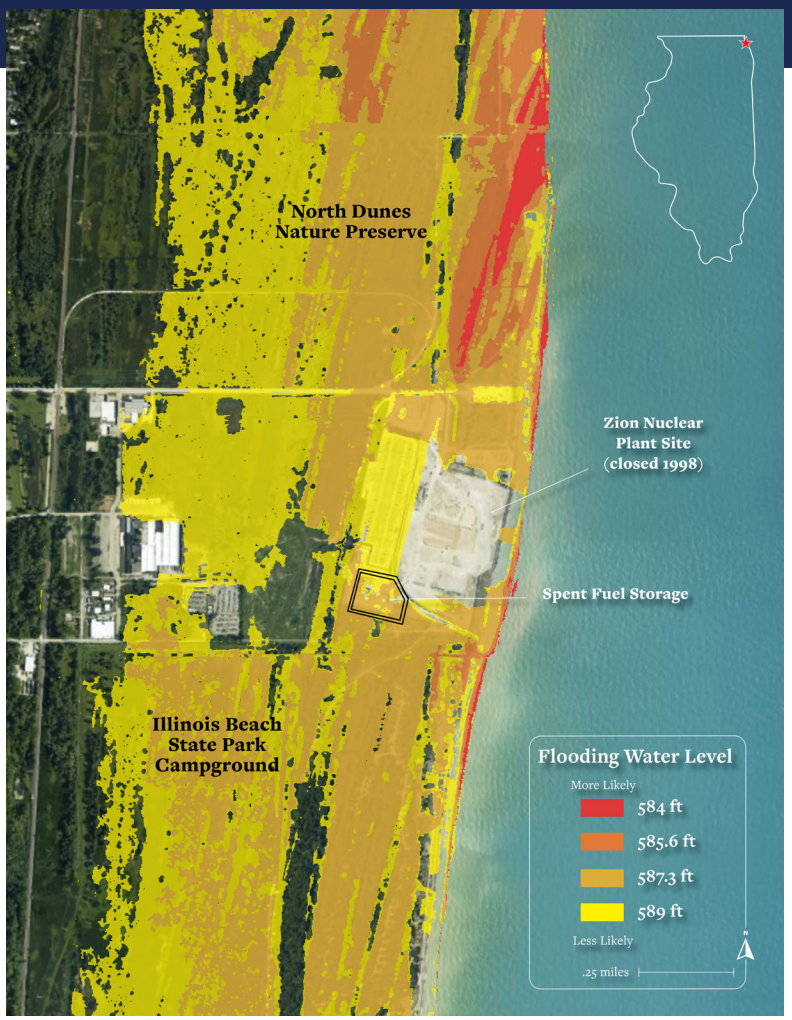
101 Shiloh Blvd, Zion, Illinois

The retired Zion Nuclear Power Plant is located 50 miles north of Chicago on Lake Michigan's western shoreline. Large quantities of highly radioactive spent nuclear fuel rods are stored on-site in concrete cannisters, and the decommissioning process has also produced several other types of low-level radioactive waste, including contaminated concrete, soils, water, and metal debris.[36] High lake levels and extreme weather have accelerated erosion in the surrounding Illinois Beach State Park, raising concerns about how well the radioactive materials are protected from the lake and surrounding ecosystem.

The Exelon Corporation shuttered the plant in 1998, and then transferred control to a nuclear services company, Zion*Solutions*, in 2010. [37] After completing decommissioning and site restoration, Zion*Solutions* plans to revert control to Constellation Energy, an Exelon subsidiary, by November 2022.[38] Although the U.S. Department of Energy had plans to move the nuclear waste by 2033, that now appears highly unlikely. [39]

While steady water levels are unlikely to reach 589 feet, wave action during extreme weather events could impact the spent nuclear fuel storage site marked in the center of the map. The sand dune and oak savannah ecosystems in the surrounding Illinois Beach State Park could be vulnerable to contamination in addition to the surrounding population. There are 29,658 people living within a three-mile radius of the site, 44% of whom live below the poverty level, and 53% of whom are racially or ethnically marginalized. [40]

Although Zion*Solutions* claims that the spent fuel storage site is protected from flooding, that assessment is based on historical flood levels.[41] Given the potential risk, it is urgent that regulators, site managers, and policymakers reevaluate whether the containment measures can handle flooding at levels that diverge from historical models. The U.S. Nuclear Regulatory Commission and Illinois Department of Nuclear Safety should scrutinize safety measures at the Zion nuclear plant site.



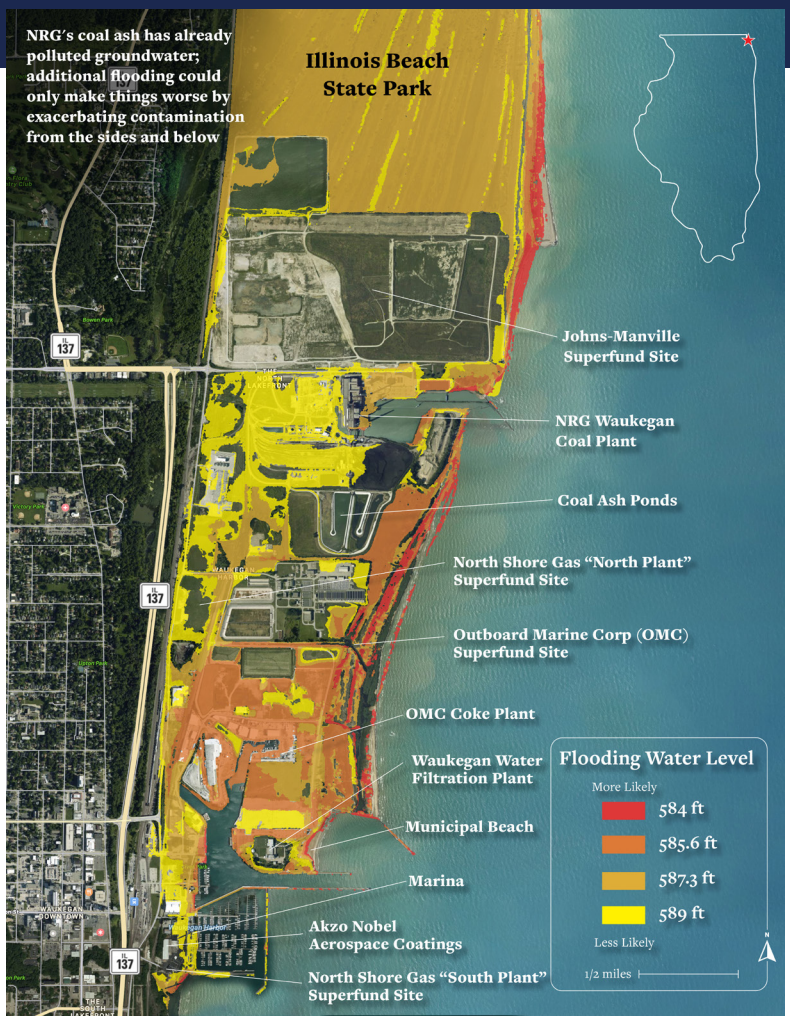
Waukegan

Six Highlighted Facilities

The City of Waukegan has a cluster of industrial facilities along the shore that are at risk from flooding. Just east of downtown, the municipal beach, water filtration plant, and marina are situated close to four Superfund sites, an aerospace production facility, and a coal plant with coal ash ponds, all within approximately two square miles. Of the 85,000 people who live within a mile of these industrial sites, 45% live below the poverty line and 82% are people of color.[42]

At the top of the map, Illinois Beach State Park is the gem of the state park system and the state's most longstanding nature preserve.[43] The park's environmentally sensitive wetlands are recognized for their international importance, home to threatened and endangered species such as Piping Plover and Blanding's Turtle.[44] Unfortunately, the beach is rapidly eroding, losing over a hundred acres in the past 80 years and accelerating due to climate change.[45] If high lake levels and extreme weather ruptured containments at the nearby industrial facilities, contamination could cause further damage to the ecosystems within the state park.

Three Superfund sites in Waukegan are on the National Priorities List: the Johns-Manville Corporation and the Outboard Marine Corporation sites are located along the shore, and the inland Yeoman Creek Landfill is located on a wetland flood plain, beyond the scope of this map.[46] A Superfund site is a contaminated or hazardous site managed by the U.S. EPA Superfund program, which was established with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).[47] The costs of remediation are borne by potentially responsible parties (PRPs) as well as taxpayers. The National Priorities designation indicates that these sites are among the nation's most contaminated and must undergo a more intensive remediation process. This process can take years, and local communities remain vulnerable to exposure until remediation.



Near the bottom of the map, Waukegan Harbor has been designated as a Great Lakes Area of Concern (AOC).[48] In 1990, the Illinois EPA formed the Waukegan Harbor Citizens Advisory Group (CAG) which is a community organization that has helped carry out a Remedial Action Plan for the AOC, and it monitors and facilitates remediation of the four shoreline Superfund sites.[49] As per a 2007 agreement, the area is now overseen by the WEC Energy Group, Inc. (formerly the Integrys Energy Group).[50]

JOHNS–MANVILLE CORPORATION SUPERFUND SITE

843 JohnsManville Place, Waukegan, Illinois

The Johns-Manville Corporation plant in Waukegan was once the world's largest asbestos manufacturing facility.[51] It is now a 350-acre Superfund site on the National Priorities List, located just south of Illinois Beach State Park.[52] Asbestos is the main contaminant on site, but lead, chromium, and xylene are present too.[53] Even though the Superfund area is elevated and does not appear to have much of a flooding risk on the map, its proximity to the lake and the rapid rate of erosion in the surrounding dune ecosystem are concerning.

Asbestos was used for home insulation, ceiling tiles, vehicle parts, and other uses for decades, until the public became more widely aware of its hazards and the U.S. began regulating its use in the 1970s.[54] Extensive exposure can result in lung disease, cancer, mesothelioma, and asbestosis. While asbestos is most dangerous as an air pollutant, it can spread through water and become airborne when contaminated water evaporates, thereby contributing to air quality concerns.[55]

The U.S. EPA and the State of Illinois have conducted several phased cleanups of the Johns-Manville site since 1988 to consolidate waste, install protective covers, implement land use restrictions on the surrounding area to minimize exposure to contamination, and initiate periodic air, soil, and groundwater testing.[56] After the facility ceased operations in 1998, all former buildings were demolished in 2000 and 2001. Follow-up sampling identified seven additional areas of asbestos contamination outside of the Johns-Manville fence line.[57] Asbestos-containing material has been removed from some of these adjacent areas but remains in others, such as the environmentally -sensitive Nature Preserve Road.

NRG WAUKEGAN COAL PLANT

401 E Greenwood Ave, Waukegan, Illinois

The NRG Waukegan Generating Station was a coal-fired electric power plant in operation for nearly a century until it closed in June 2022, but NRG's transition plan is still unclear.[58] The property is bordered by multiple Superfund sites to the north and south. If water levels from lakeshore flooding reach just 584 feet, most of the coal plant site could be submerged. This includes areas immediately adjacent to the coal ash ponds located in the southern portion of the facility—which also contain coal ash outside the ponds. Although the map does not show the ponds underwater, flooding could infiltrate the adjacent areas containing coal ash, pose a risk to the structural integrity of the ponds, and cause contaminant leaching from ash outside of the ponds.[59] This is concerning because coal ash contains a number of toxic substances.

This plant reported violations of its Clean Water Act permits for the last thirteen quarters, dating back to at least October 1, 2018.[60] In 2019, the Illinois Pollution Control Board confirmed that the site has unsealed historic coal ash, slag, and fly ash pits. Evidence from soil borings shows that, in the area surrounding the coal ash ponds, coal ash is buried as deep as 22 feet below ground. There are indications that the coal ash contaminants are leaching into groundwater.[61] There have been 394 exceedances of the Illinois' Groundwater Quality Standards between 2010 and 2017 from antimony (2 exceedances), arsenic (97), boron (169), cadmium (1), chromium (2), selenium (2), sulfate (57) and total dissolved solids (63).[62] These compounds present various negative health effects when encountered in high concentrations, ranging from minor irritation or inflammation to gastrointestinal problems, disease, or cancer.[63]

ELPC has been working to pass and implement coal ash cleanup legislation at the state level, including supporting a new bill this year to specifically focus on Lake Michigan shoreline communities.[64] NRG's pollution is a long-standing problem. Community members are concerned that they'll be saddled with remaining contamination, which poses a risk to their drinking water source.[65] State and local authorities must hold NRG responsible for cleaning up before rising lake levels make the situation any worse.

NORTH SHORE GAS "NORTH PLANT" SUPERFUND SITE

3001 Grand Avenue, Waukegan, Illinois

The shuttered North Shore Gas "North Plant" Superfund site is a former Manufactured Gas Plant (MGP). It is not on the National Priorities List (NPL), but U.S. EPA considers it to be an NPL-caliber site and is addressing it through the Superfund Alternative Approach.[66] The site is currently in the Remedial Investigation and Feasibility Study phase of the Superfund process.[67] The 16-acre site is likely contaminated with tar and other residuals from plant operations from the former MGP.[68] Flooding could reach much of the site if water levels reached 587.3 feet, but if levels reached 589 feet, flooding could extend deep into the site, as shown in yellow on the map.

MGPs were industrial facilities used until the mid-1900s for gas or coke production. Waukegan was home to three such plants, making it a hotspot for associated pollutants. Manufactured gas plants around the country typically created coal tar as a byproduct, which can contaminate surface soils, subsurface soils, and surrounding groundwater.[69]

The U.S. EPA conducted contaminant removal at the North Shore Gas "North Plant" in 2014 to address many immediate threats to human health and the environment. In 2019 and 2020, North Shore Gas completed a supplemental site investigation of contamination and monitored groundwater samples for the remaining contamination at the site.[70] They will be submitting a new report detailing remaining contaminants to U.S. EPA for review. Once approved, the agency will share its plan to clean up the site for public comment. The U.S. EPA should consider climate conditions as part of this review to ensure cleanup plans are suited to changing water levels and extreme weather conditions.

OUTBOARD MARINE CORPORATION (OMC) SUPERFUND SITE

200 Sea Horse Drive, Waukegan, Illinois

The Outboard Marine Corporation (OMC) Superfund site is a 100-acre site on the National Priorities List.[71] The former plant manufactured outboard motors designed for recreational and fishing boats with an engine, gearbox, and propeller in one unit.[72] Contaminants of concern include polychlorinated biphenyls (PCBs), which OMC used in hydraulic fluids and trichloroethene (TCE), a chlorinated solvent that OMC used to degrease newly made parts. The site also includes the former Waukegan Manufactured Gas and Coke Plant (WCP), which used an industrial process of thermal distillation to produce fuel from coal (coke) that burns hotter than coal.[73]

In 2014–15, OMC remediated the site for PCBs, which have a wide variety of carcinogenic and non-carcinogenic effects, and cleanup is now in the monitoring phase.[74] Under the Superfund Redevelopment Initiative, the City of Waukegan is aiming for mixed-use development of the site after cleanup finishes.[75] If water levels or high waves reached 585.6 feet during an extreme weather event, water could impact the OMC site, as indicated in orange on the map.

AKZONOBEL AEROSPACE COATINGS, INC.

1 E. Water Street, Waukegan, Illinois

AkzoNobel Aerospace Coatings is an active facility that specializes in paints and coatings for aircraft, such as primers, thinners, fillers, gloss, resins, and other products.[76] The plant is 6.2 acres, and it sits within the North Shore Gas "South Plant" Superfund site, adjacent to Waukegan Harbor.[77]

The AkzoNobel facility presents its own potential sources of environmental contamination, independent of the surrounding Superfund sites, which could be affected by extreme weather events during periods of high water levels as indicated by yellow on the map. In 2019, AzkoNobel discharged glycol ethers, chromium, diisocyanates, ethylbenzene, methyl isobutyl ketone, N-butyl alcohol, toluene, and xylene, according to the facility's Toxics Release Inventory.[78]

According to the U.S. EPA, long-term exposure to glycol ethers may have neurological and blood effects, including fatigue, nausea, tremor, and anemia.[79] Certain chromium compounds have been found to be carcinogenic in animal studies. Long-term exposure to xylenes in amounts over safe limits can damage the central nervous system, liver, and kidneys.

NORTH SHORE GAS "SOUTH PLANT" SUPERFUND SITE

3001 Grand Ave, Waukegan, Illinois

The North Shore Gas "South Plant," a former Manufactured Gas Plant, is now a 20-acre Superfund site shown at the bottom of the map.[80] It is not on the National Priorities List, but U.S. EPA considers it to be an NPL-caliber site and is addressing it through the Superfund Alternative Approach.[81]

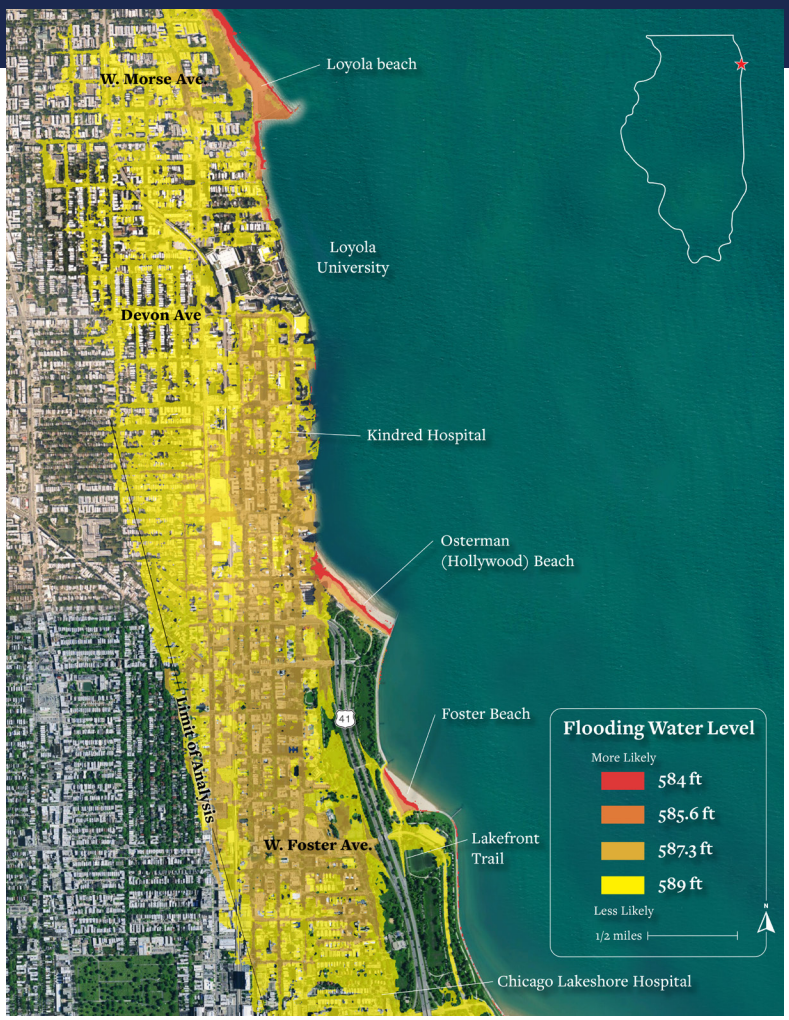
Dense non-aqueous phase liquid is the primary source of groundwater contamination at this plant.[82] This is a class of environmental contaminants, including coal tar, which have the potential to act as long-term sources of dissolved phase contaminants. Coal tar is a complex mixture of chemicals and contains volatile or semi-volatile organic compounds. Despite the name, coal tar has a very low viscosity, can migrate, and can easily form a tar-water emulsion which is difficult to contain.[83] This is of particular concern because of its proximity to the lake. The areas surrounding the plant could be flooded if water levels reached 584 feet, as shown in orange on the map. In high water level conditions with extreme wave action, the facility itself could be affected as well, as indicated by yellow on the map.

The site is currently in the Remedial Design/Remedial Action stage of the Superfund process. In May 2020, North Shore Gas planned to begin extracting undissolved tar-like liquids in the groundwater beneath its South Plant after finishing construction and testing of its extraction system to remove the tarry substance. The removal of the liquids is expected to be completed by 2028.[84]

Chicago's Far North Side

Community Infrastructure

There are no major permitted industrial facilities in Chicago's Rogers Park, Edgewater, and Uptown neighborhoods. However, climate change impacts on high water levels threaten hundreds of homes, businesses, and other infrastructure as far as half a mile inland. The Edgewater neighborhood is in the center of the map, stretching from Foster to Devon Avenues, neighbored by Rogers Park to the north and Uptown to the south. All three neighborhoods are densely populated, with over 55,000 people each.[85] Uptown and Rogers Park are the city's most racially diverse communities and nearly a quarter of local residents live below the poverty line.[86]



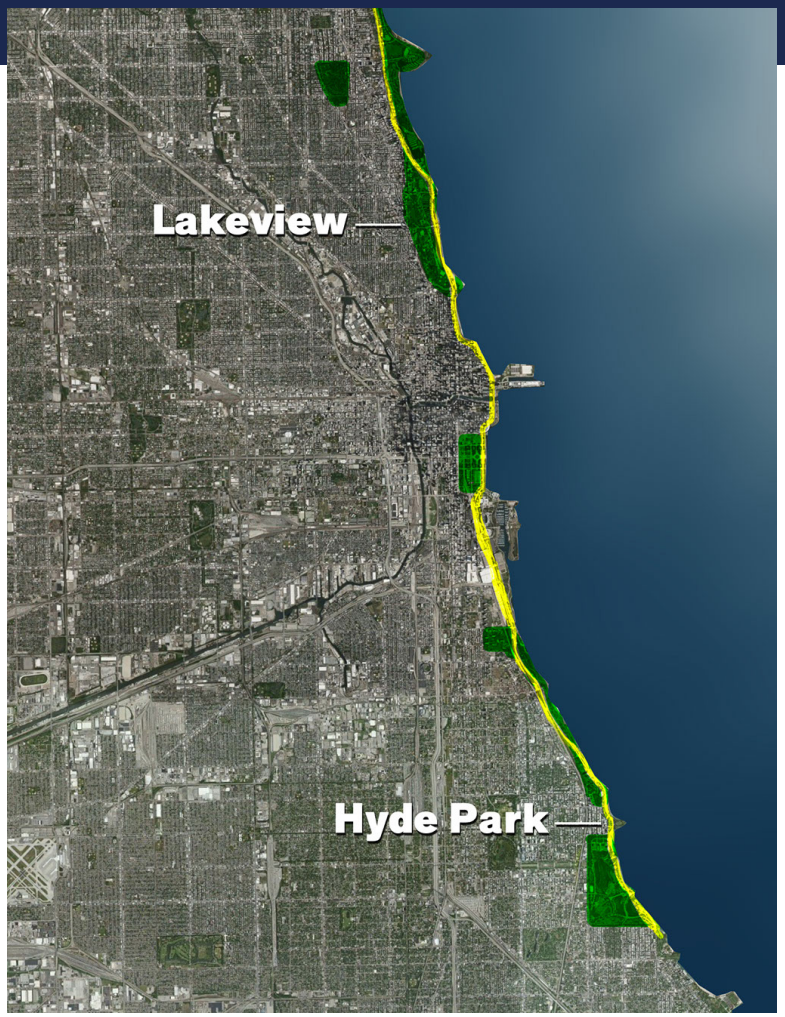
Rising lake levels and extreme weather have already caused extensive damage in the area in recent years.[87] In 2019–20, when Lake Michigan reached 582.2 feet above sea level, wind gusts of 35 mph contributed to waves over 9 feet high, battering shoreline apartments and businesses.[88] Just north of this map, the Rogers, Howard, and Juneway beaches disappeared under high waves, and larger beaches shrank, prompting emergency shore stabilization and protection measures in Chicago and the northern suburbs.[89]

If lake levels reached 584 or 585.6 feet, the large and popular Loyola, Osterman (Hollywood), and Foster Beaches would be further inundated, as shown in red and orange on the map. Wave action during extreme weather events could cause damage far into the neighborhood, as shown in mustard and yellow on the map. This could put more than a dozen hospitals and schools at risk, including Chicago Lakeshore and Kindred Hospitals; Heartland and Hamdard healthcare facilities; McCutcheon, Goudy, Swift, and Kilmer public schools; Sacred Heart and other private schools; and the exterior buildings of the Loyola University campus.

Even localized flooding in the Edgewater neighborhood would have a cascading effect on the city's transportation system. Eight Chicago Transit Authority bus routes run at street level through this neighborhood, the Berwyn, Thorndale, and Granville red line stations run through the center of the map, and DuSable Lake Shore Drive (U.S. 41) terminates at Hollywood Avenue. Although the train lines and highway are elevated, access to entry and exit points could be limited if the stations and outlet streets were to flood. Bicycle transportation routes could also be inundated by flooding in extreme conditions, including neighborhood greenways and the Lakefront Trail, which begins by Osterman Beach and continues south between the highway and the shore.

Chicago's Central Shoreline

Transportation Infrastructure



Chicago's central lakeshore is home to public parks, beaches, and transportation systems, largely built on landfill. While parkland can often absorb flooding, concrete is not so resilient.[90] DuSable Lake Shore Drive cuts through the parks for 16 miles, carrying up to 155,000 drivers and 69,000 transit riders a day.[91] Next to the highway, up to 100,000 people walk, bike, and roll on the Lakefront Trail a day.[92] Extreme lakefront conditions that impede these corridors can have widespread effects on transportation throughout the area.

We consider this entire corridor to be one large hotspot and have provided two close-up maps that illustrate potential flooding impacts on the North and South Sides of the city. High lake levels have already flooded the highway several times in the past few years, snarling vehicular and bus traffic, but the bike trail is even more exposed.[93] Buckling concrete caused by high water forced trail closures for months in 2019-2021 near Fullerton, Oak Street, 41st street, and Promontory Point.[94]

From 1996-2014, the Army Corps of Engineers spent $536 million to reinforce eight miles of shoreline infrastructure, but high waves in 2019–20 caused another estimated $500 million in damages.[95] In 2021, the Chicago Department of Transportation and the Army Corps began a $1.5 million project to reinforce Morgan Shoal and repair the trail near Promontory Point in Hyde Park.[96] In 2022 the Army Corps announced a new $3 million study to look into reinforcing additional miles of Chicago shoreline.[97]

If water levels reached 584 feet, the lake could wash onto the Lakefront Trail at both Belmont Harbor and 57th street, as shown in red in these maps. At higher levels, the water could stretch onto the highway in both maps, as shown in orange. And high wave action during extreme weather events could impact

larger areas of the community, affecting homes, businesses, and public facilities.

Since 2013, transportation authorities have been working on plans to rebuild the northern half of the highway and are currently seeking community feedback.[98] While this project does have the potential to mitigate the risk of flooding on the road and path by adding more absorptive park land to the shore, the project will likely not protect all neighboring communities from flooding.[99] Floodwater could still bypass the highway on the north and south ends, flood underpasses, and come from other sources such as rivers and sewers. Rebuilding the road does provide the opportunity to shift users from car to transit – an important step to reduce climate change pollution and transport more people with less concrete. During flooding, buses can be rerouted to higher elevation streets, providing more resilient mobility options. Developers must prioritize transit-only lanes and facilitating bus movement along the Drive, rather than adding lanes for personal vehicles. As the largest road project contemplated in the city, this is a unique opportunity to make Chicago's transportation system more efficient and sustainable.

Chicago's South Shore Neighborhood

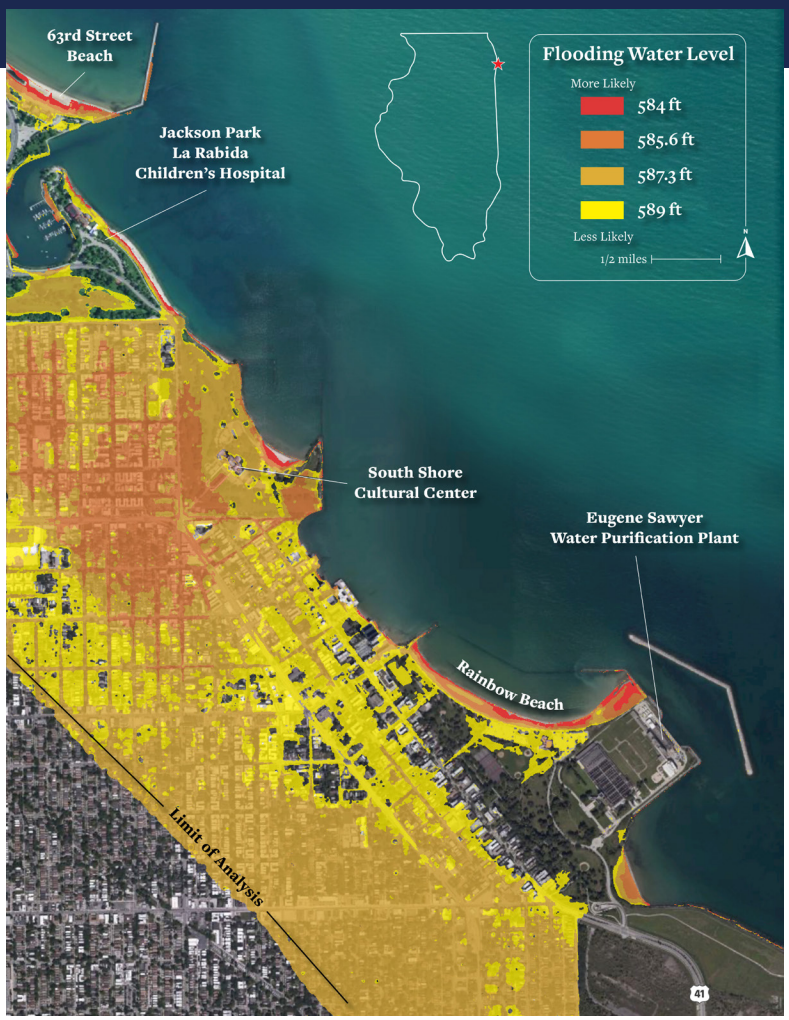
Community Infrastructure

As its name would suggest, the South Shore neighborhood is built close to the water, making it vulnerable to high water levels and extreme weather. High-water conditions have already caused damage in recent years, and future extreme weather events could affect homes, businesses, and vital resources as far as half a mile inland. The neighborhood is densely populated with a population of 51,000 people, 93% of whom are black, and 31% of whom live below the poverty line.[100]

During the January 2020 flood, water from Lake Michigan inundated streets several blocks from the lake.[101] ELPC's analysis includes these previously flooded areas and shows flood risk even further inland. The accompanying map shows that the northern area of the South Shore neighborhood could be submerged by flood events if lake levels exceeded 585.6 feet, and nearly the entire neighborhood could be flooded at levels exceeding 587.3 feet.

In addition to property damage, future flooding could impact several hospitals and educational facilities, including La Rabida Children's, South Shore, and Jackson Park Hospitals; Mile Square, Access Brandon, and Chicago Family Health Centers; the South Shore Public Library; and the Black, Bradwell, Bouchet, O'Keeffe, and Powell public schools. Flooding could damage culturally significant sites, including the historic South Shore Beach Apartments, Rainbow Beach, South Shore Cultural Center, and Jackson Park.

City transportation infrastructure could also be affected by climate change-induced flood events. The Metra electric line runs at grade level through the neighborhood, where three train stops—South Shore, Windsor Park, and Metra Cheltenham—could be inundated. There are twelve bus routes that operate at grade level through this neighborhood, although they could be rerouted in the event of high flood waters.



The Army Corps of Engineers, the Chicago Department of Transportation, and the Chicago Park District's efforts to reduce lakefront erosion extend primarily to public lands. As a result, lakeside private residential apartment buildings on the South Side remain vulnerable. Given the wealth disparity between the north and south sides of the city, South Shore residents have expressed concern that the North Side of Chicago has more resources for repair, maintenance, and resilient infrastructure than South Shore, one of the most at-risk neighborhoods in Chicago.[102] There is an urgent need to commit resources and devise a comprehensive plan for protecting the shoreline as a whole.

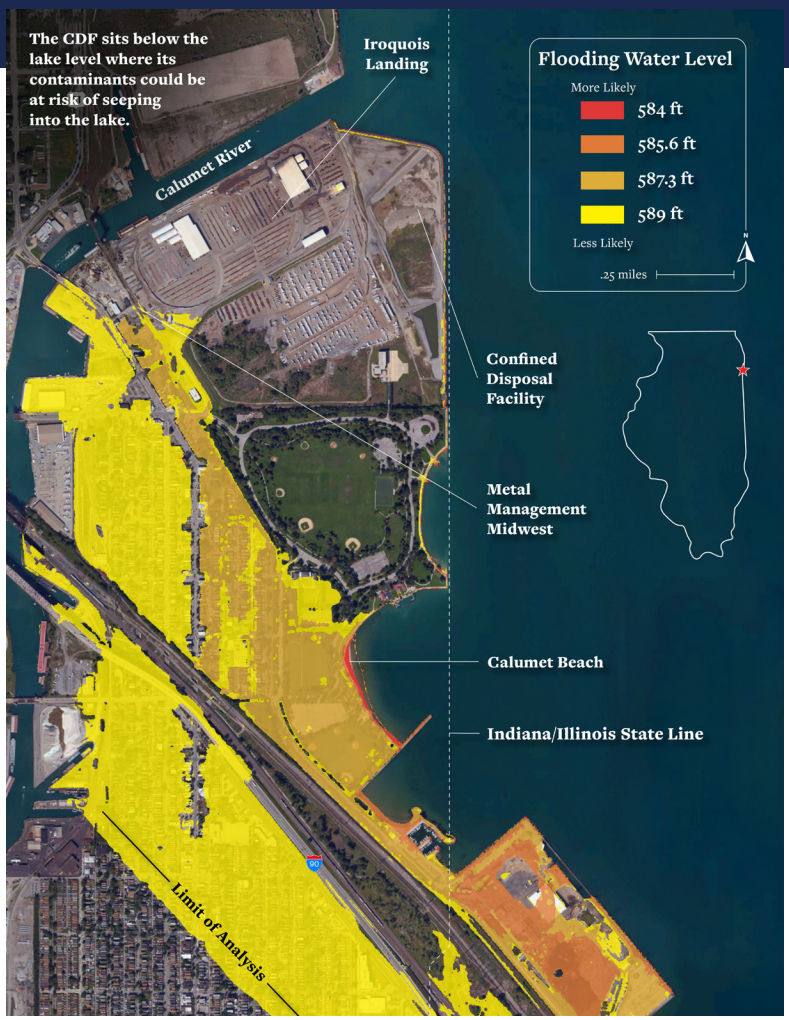
East Side Neighborhood

Three Highlighted Facilities

On the Southeast Side of Chicago, the East Side neighborhood is bordered by Lake Michigan and the Indiana state line to the east, the Calumet River to the north and west, and Eggers Grove to the south, and it is bisected by the Chicago Skyway. It is an environmental justice community, home to 21,000 people, 82% of whom are Latino, and 26% of whom live below the poverty line.[103] Community organizations and residents have long mobilized to fight threats to public health and the environment, including threats outside the limit of this analysis. The accompanying map shows the northern portion of the neighborhood, where several industrial facilities are clustered close to residential and recreational areas. This community has already experienced flooding in recent years and remains vulnerable to high water, erosion, and pollution spread, especially as climate change exacerbates extreme weather.

At the top of the map, north of the Calumet River, lies the shuttered U.S. Steel South Works site that closed in 1992.[104] Although the Illinois EPA stated in 1997 that no further remediation was legally required, the latest developer with plans for redevelopment fell through in 2020, reportedly concerned by remaining soil contamination.[105] On the south side of the river, we highlight three facilities in this report that could be affected by high water conditions: the Chicago Confined Disposal Facility to the east along the state line, the Iroquois Landing shipyard in the middle, and Metal Management near the bend in the river.

South of these sites, much of the historic residential community sits below street level. From the 1850s to the 1910s, the city raised the street level up to ten feet to give the new modern sewer system sufficient gravity flow.[106] Rather than raising many older homes, residents just built new doors or staircases to match the higher streets, while their yards and first floors remained low, putting these homes at risk of flooding today. Along the shore, recreational amenities include Calumet Park, Calumet Beach, Munson Beach, and Calumet Yacht Club. During high water level conditions, extreme weather could affect areas further inland, as indicated in mustard on the map, inundating both recreational and residential infrastructure. In the most extreme conditions, water could even reach south of the elevated Chicago Skyway (U.S. 90) which bisects the neighborhood. Given the cumulative impact of existing environmental hazards in the area, climate change could exacerbate the disproportionate burden facing this community.



CHICAGO CONFINED DISPOSAL FACILITY
843 JohnsManville Place, Waukegan, Illinois

The Chicago Confined Disposal Facility (CDF) is a U.S. Army Corps of Engineers dump for polluted sediment dredged from the Calumet River and Harbor.[107] This dredged material contains high levels of PCBs, mercury, and arsenic, according to 2017 and 2019 reports.[108] West of the CDF, the soil contains waste from iron and steel manufacturing, such as foundry sand, coal, wood, iron, and miscellaneous trash. Tests indicate that groundwater in this area tends to flow eastward, carrying leachates toward the CDF and Lake Michigan.[109] Although the map does not appear to show a great risk of flooding, the contents of the CDF currently sit below the lake level, rendering the facility's contaminants vulnerable to more turbulent shores. In fact, a 1986 report demonstrated that water levels in the CDF fluctuate in the long-term with lake levels, indicating the waters are hydrologically connected.[110] If the surrounding barriers were to erode or breach, the CDF's exposed position on the lakeshore means it may be more vulnerable to damage, runoff, and seepage from storm surges or shoreline erosion deviating from historical norms.

The facility is located on land owned by the Chicago Park District in Chicago's East Side, east of the Iroquois Landing ship terminal and north of Calumet Park. In 2014, the CDF's operational lifespan was extended with construction of a drying pad.[111] The CDF's expected lifespan was supposed to end in 2022, when it is projected to be at capacity in its current state. However, the Army Corps plans to extend the timeline by building a vertical expansion at the same location, capable of housing an additional 530,000 cubic yards of dredged material. Several local environmental groups have come out in opposition to this expansion, including ELPC.[112]

Despite the presence of PCBs, mercury, and arsenic in the sediment, the Army Corps did not test for these pollutants in its routine water quality monitoring. ELPC has worked with the local community to push for these pollutants to be included in water quality testing.[113] As a result of these efforts, the most recent permit issued by Illinois EPA requires the Army Corps to test for PCBs, mercury, and arsenic during dredging events and once a year, but report results monthly. There are 3,536 people who live within a one-mile radius of the facility—69% of the population live below the poverty level, and 94% of the population are people of color.[114]

According to the EPA, mercury is a neurotoxin that causes adverse health effects in humans of all ages and brain damage in infants. Mercury has a long retention time in soils, and contaminated soils or sediments may continue to release mercury into their surroundings for decades.[115] When mercury is released into the lake, it is converted by waterborne microorganisms into methylmercury, an organic compound which bioaccumulates and becomes more concentrated as it moves up the food chain. In this form, it affects numerous fish species, waterfowl, and mammals that eat fish, including humans.[116] Polychlorinated biphenyls (PCBs) are known to have adverse health effects and are potentially carcinogenic. PCBs negatively affect the immune, reproductive, and endocrine systems, and have neurobehavioral effects.[117]

The public's concerns about the CDF's ability to contain its contents and their associated pollutants have only grown as climate change risks increase. Federal, state, and local authorities must reassess the safety of the site's containment measures, both as it stands now and as plans for the expansion of the site are considered.[118]

IROQUOIS LANDING, CHICAGO

3600 E 95th St, Chicago, Illinois

Iroquois Landing is a 100-acre open shipping terminal, located on the Calumet River in the East Side neighborhood of Chicago. In 2012, the Army Corps tested sediment from the Calumet River and Harbor, indicating the presence of arsenic, chromium, copper, cyanide, lead, manganese, and various other pollutants, some of which may be attributed to leaching from Iroquois Landing.[119] Earlier groundwater testing in 2005 by the Army Corps from the Landing's eastern border with the adjacent Confined Disposal Facility, indicated high pH levels and the presence of manganese, zinc, ammonia, and phosphorus pollutants. Although the map does not show flooding within the property, higher lake levels, heavier waves, and extreme weather could contribute to erosion for this historically toxic area.

Iroquois Landing is managed by the Illinois International Port District and its main tenant is the North American Stevedoring Company (NASCO), a bulk solid material handler which operates under a Clean Air Act permit. The Chicago Police Department's First Area Police Headquarters Heliport is also on the site. The former marshland was used as a landfill and steel mill until the 1970s, when the Chicago Port Authority opened its terminal facilities on the northern half of the property. The southern half was used until at least 1982 as a landfill area for municipal and steel mill industrial solid wastes.

According to the EPA, there are 7,396 people who live within a one-mile radius of the facility—73% of the population lives below the poverty level, and 95% of the population is racially marginalized.

Given the known presence of toxic pollutants on the site, the property owners and Army Corps should conduct further research to determine the potential for pollution to spread from this area and work to mitigate those risks.

METAL MANAGEMENT, CHICAGO

9331 South Ewing Ave, Chicago, Illinois

Metal Management is a closed scrap metal recycling yard on the Calumet River just west of the Iroquois Landing port facility in the East Side neighborhood.[120] Due to the site's history in the steelmaking industry, its groundwater quality is poor and much of the ground is likely composed of industrial fill material (silt, slag, cinders, ash, foundry sand), along with harbor/river dredging, construction material, coal, steel cuttings, and other waste materials. If these pollutants remain, an extreme flood could spread them into the surrounding community, river, or lake. If water levels reached 578.3 feet above sea level, the southern portion of the facility could flood, as shown in mustard on the map. If water levels reached 589 feet above sea level, part of the facility along the Calumet River would flood as well, as shown on the map in yellow.

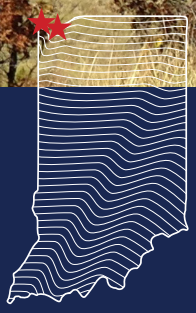
The facility is owned by Metal Management Midwest Inc., a subsidiary of Australia-based metals and electronics recycler Sims Limited. It has been closed since 2015-16 and is currently not listed as active on Sims Limited's website. When active, the facility operated a metal shredder, registered as an emitter of lead and chlorofluorocarbons (CFCs) under Clean Air Act and Clean Water Act permits.[121] The site continues to be in noncompliance with its Clean Water Act permit for failing to submit annual facility inspection reports from 2012 through 2014.[122]

According to the EPA, 14,037 people live within a one-mile radius of the facility, 66% of whom are below the poverty level, and 95% of whom are racially marginalized.

EPA should take measures to determine the site's current state of remediation, as well as to assess the potential harms of pollution spread through surface runoff or by groundwater propagation.

MAPS

INDIANA



Indiana's 45-mile Lake Michigan shoreline is a unique mix of heavy industry, residential communities, and protected natural areas. Increased flooding could spread lingering pollutants, such as heavy metals, coal ash, and steel byproducts, to communities and the lake.

High lake levels and extreme weather will also exacerbate shoreline erosion. In 2020, storms caused extensive damage to beaches, roads, and seawalls in Whiting, Ogden Dunes, Portage, Dune Acres, Beverly Shores, and other communities. Flooding threatened public infrastructure for gas and water and cost millions in shoreline repairs and mitigation measures. The Indiana Dunes National Park also faces major erosion to its beaches from increased lake levels and pollution threats from the nearby steel mills.[123] The highly visited park has a regional economic impact of $500 million.[124]

Indiana's residential communities and protected natural areas already face pollution risks from nearby industrial facilities. High water could exacerbate erosion and pollution risks from a shuttered coal plant in Hammond and a steel mill in Gary.

HAMMOND

Just east of the Illinois border, Hammond is home to 76,000 people.[125] Automobile, chemical, and metal manufacturing plants have contributed to unsafe levels of air and soil pollution for years. Flooding is a growing concern now too. Rainfall-induced flooding in the Grand Calumet and Little Calumet Rivers has washed toxic pollutants from industrial landfills into residential neighborhoods of Hammond and East Chicago next door. The now-shuttered State Line Coal Plant site is located on a peninsula in the lake. Increased flooding could erode the site and contaminate surrounding communities and the lake.

GARY

Now home to 68,000 people, Gary was built around the steel mills along Lake Michigan.[126] Like its neighboring communities, Gary has endured extensive water, air, and soil pollution for over a century, much of it emitted by U.S. Steel Gary Works. Additional flooding could contaminate the lake and nearby communities with heavy metals, volatile organic compounds, PCBs, and several other pollutants. To prevent contaminated sites from flooding during extreme weather events, industries and local authorities have erected protective barriers along the shore. Unfortunately, these barriers accelerate beach erosion in the nearby Indiana Dunes National Park because they interrupt natural sand deposition processes. To tackle the twin challenges of pollution and erosion will take coordinated efforts from municipalities and states.

State Line Coal Plant

103rd Street, Hammond, Indiana

The State Line Coal Plant was active from 1929 to March 2012, it was demolished in 2014.[127] The facility was located on Hammond's shoreline, on the border with Illinois, just east of the Chicago Skyway. When active, it ran four coal-fired generating units under Clean Air Act, Clean Water Act, and Resource Conservation and Recovery Act (RCRA) permits.[128] Though the plant was demolished and removed, the extent of the site's topsoil contamination is unclear, raising concerns about the possibility of lingering pollutants manifesting as water pollution.

If water levels reached 585.6 feet above sea level, much of the site and surrounding area could be flooded, as shown in orange on the map. Depending on the extent to which the site has been remediated, flooding may carry remaining pollutants to the lake and surrounding area as runoff.

A 1999 environmental site assessment (ESA) confirmed the presence of polynuclear aromatic hydrocarbons (PAHs), a class of carcinogens that also cause reproductive impairment in fish, at concentrations below IDEM cleanup objectives in the site's soil.[129] However, it is unclear if testing for contaminants other than PAHs or VOCs took place. The property has changed hands multiple times making it difficult to place responsibility for remediation. In 2012, the National Resources Defense Council and ELPC called for independent evaluations of the site.[130]

During its lifetime, the State Line Generating Plant was considered the area's heaviest source of air pollution, as a heavy emitter of nitrogen oxides, sulfur dioxide, and mercury.[131] In 2009, EPA initiated an enforcement action, citing 4,770 minutes of opacity ("soot and smoke") violations from 2004 through 2008. In 2010, ELPC and other environmental groups filed a notice of intent to sue Dominion Resources over the plant's opacity violations. In 2013's United States v. Dominion Energy, Inc., a Consent Decree was finalized in which Dominion agreed to shut down the plant, pay a $3.4 million civil penalty, and spend $9.75 million on environmental mitigation projects.[132] The land was sold in 2012 to Texas-based BTU Solutions; some was purchased in 2013 by Sam Townline Development, Inc.[133] Then, forty-four acres were later sold for a project sponsored by the city of Hammond to build a data center, Digital Crossroad, which opened in October 2020.[134]

While State Line was most known for its air pollution violations, the coal plants also produced several kinds of solid waste, known collectively as coal ash, which was historically dumped on site. Coal ash can leach heavy metals into the surrounding water and soil, such as lead, arsenic, cadmium, and chromium. According to inspection records, 202 truck-loads of coal ash were removed from State Line, but this plant generated coal ash for nearly a century, so it is unclear whether coal ash remains as fill on site. Given the increased flood risk due to climate change, local and state officials should investigate the levels of soil contamination and how rising water levels and extreme weather could affect the site and surrounding community.

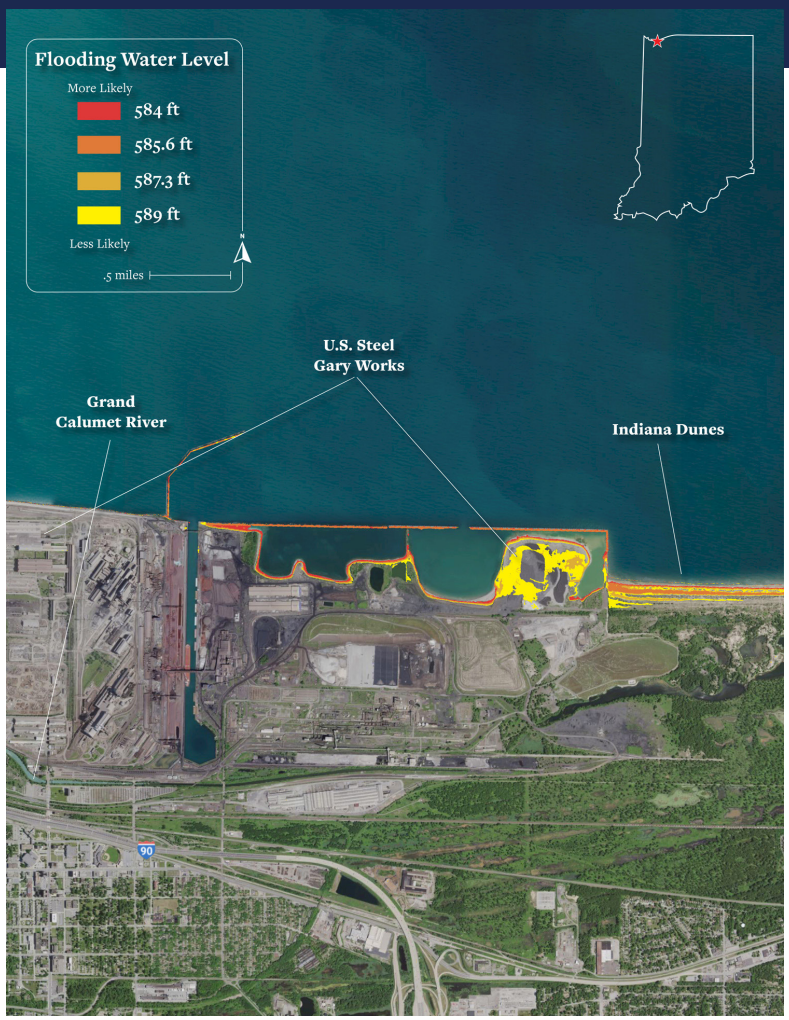
U.S. Steel Gary Works Facility

1 North Broadway, Gary, Indiana

The United States Steel Corporation (U.S. Steel) Gary Works Facility is the largest integrated steel mill in North America. Its 4,000-acre site, containing several steelmaking and finishing facilities, is located on the Lake Michigan shoreline. If the shoreline barriers surrounding these facilities failed amid extreme weather, pollutants could potentially spread off-site and into the lake. Although the majority of the facilities appear safe from flooding, if extreme weather brought high waves during high water conditions, the northeast portion of the main facility could be affected, as shown in yellow on the map.

U.S. Steel Gary Works holds Clean Air Act (CAA) and Clean Water Act (CWA) permits and is classified by U.S. EPA as a large quantity generator of hazardous waste.[135] The Hoosier Environmental Council describes the Gary Works facility as "the largest industrial polluter on the Great Lakes."[136] It discharges a host of heavy metals, VOCs, and other pollutants, including mercury, PCBs, and dioxin. As a Corrective Action Site under the RCRA, U.S. Steel is investigating the site for contamination of soil, sediment, groundwater, and surface water resulting from spills and waste disposal.[137]

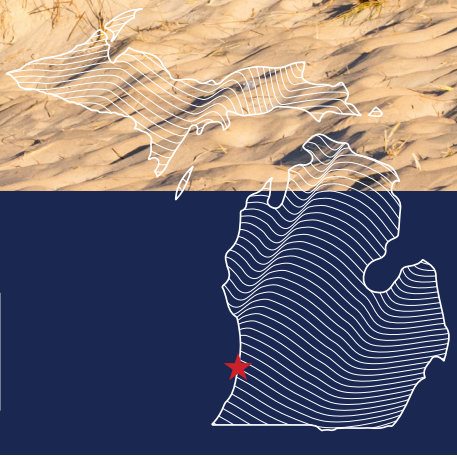
The facility lies just northeast of downtown Gary, and just west of the Indiana Dunes National Park, near the Miller and Marquette lakefront beaches. The community has experienced increased flooding in recent years. A 2019 flood caused the facility to release mercury into the Grand Calumet River.[138] In addition to its precarious lakefront position, this community is in the 74th percentile in the U.S. for air toxics cancer risk, and in the 73rd percentile in the country for the respiratory hazard index.[139] According to the EPA, there are 34,399 people who live within a three-mile radius of the facility—63% of the population lives below the poverty level, and 96% of the population is racially marginalized.[140]



The facility has a long history of violations for noncompliance with the CWA, CAA, and RCRA. Gary Works has been in significant noncompliance with its RCRA permit since June 20, 2018.[141] The facility's CWA effluent violations include exceedances of effluent mercury levels that have consistently exceeded monthly limits since 2019, reaching as high as 1,150% during the final quarter of 2019.[142] Given this history of noncompliance, local, state, and federal authorities should review this facility's preparedness to face more extreme conditions in the future.

MAPS

MICHIGAN



Michigan has the longest shoreline of any state along its namesake lake. Shoreline erosion and infrastructure damage have impacted homeowners and towns along its shore, eroding beaches, harming property, and costing millions in remediation efforts. Low-lying communities on the lakefront and those close to marinas and rivers are especially vulnerable.

In February 2020, record high water levels led the State of Michigan to launch a High Water Action Team to coordinate response, funding, and communication among all levels of government to damage to shoreline communities.[143] In March 2020, Michigan communities reported $63 million in damages to beaches and shoreline infrastructure to the Michigan Municipal League, including $16 million in South Haven, $10.7 million in Muskegon, $10 million in Frankfort, $4.5 million in Petoskey, and $3.6 million in Ludington.[144] The Michigan Department of Environment, Great Lakes, and Energy (EGLE) has identified High Risk Erosion Areas (HREAs) vulnerable to lake level changes in nearly every county bordering Lake Michigan.[145]

Michigan's many shoreline communities have been grappling with erosion damage for years. High water also exacerbates pollution risks at facilities like South Haven's wastewater treatment plant.

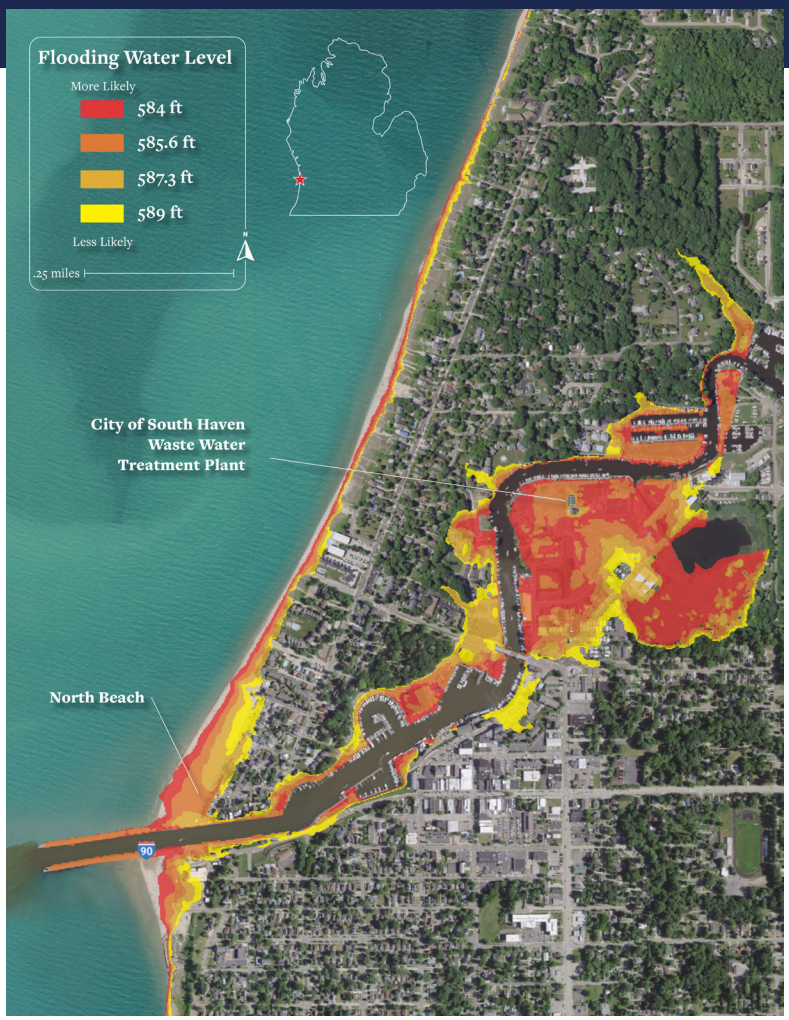
SOUTH HAVEN

South Haven is home to 4,000 people on the eastern shores of Lake Michigan, about halfway between the Indiana border and Grand Rapids.[146] The city is built around the Black River, a slow-flowing stream that tends to mirror water levels in Lake Michigan. High lake levels, strong winds, and drops in atmospheric pressure have contributed to more frequent flooding in recent years, including three separate floods in 2019 and 2020 alone. In addition to damaging property and infrastructure, flooding increases the risk of serious water pollution from South Haven's wastewater treatment plant, which is located in a low-lying area along the Black River.

South Haven residents have suffered from numerous sewer overflows, contaminating the river and lake with pollutants including total suspended solids, phosphorus, nitrogen/ammonia, E. coli, fecal coliforms, and mercury resulting in beach closures. Higher water levels and extreme weather fueled by climate change exacerbate these problems.

City of South Haven Wastewater Treatment Plant

620 E Wells Street, South Haven, Michigan



The South Haven Wastewater Treatment Plant is located on the Black River near Lake Michigan. The plant contains clarifier tanks and other infrastructure that could be inundated with water if lake levels reach 584 ft. above sea level, as shown in red on the map.

Despite improvements to South Haven's sewers and pump systems from 2017 to 2018, the plant has overflowed into the Black River multiple times, including in October 2017, November 2019, and June 2021.[147] These overflows polluted the river with sewage and biosolids, and forced beach closures throughout the area. The June 2021 overflow was particularly severe as 100,000 gallons of partially treated wastewater spilled after heavy rains. [148]

According to the U.S. EPA, 7,651 people live within a three-mile radius of the facility—25% of the population live below the poverty level, and 20% of the population is racially marginalized.

Public officials appear to be moving toward taking permanent anti-flooding measures—in February 2020, public works officials requested $1.2 million in funding to improve the plant's pumps and prevent further sewage overflows, and in May 2020, the city placed temporary flood barriers as a mitigating measure. However, the plan to construct permanent walls is still in the design phase.[149] Experts estimate it will cost $20 million to protect the wastewater treatment plant and other shoreline infrastructure.[150] Thinking beyond historical models, local leaders should plan for the wide range of potential climate change impacts to protect South Haven residents from pollution and flooding.

Recommendations & Conclusion

This report highlights how higher Lake Michigan water levels, whipped by wind and heavy waves and exacerbated by climate change, threaten facilities and communities along the lakeshore. We must rethink the Lake Michigan shoreline's infrastructure in light of these changing conditions. Mitigating climate change requires strong public and private sector actions to reduce greenhouse gas emissions from Great Lakes states, our nation, and countries around the world. Adapting to extreme water levels will require significant federal, state, and local financial investments and fundamental policy shifts as explained below.

FEDERAL RECOMMENDATIONS

Federal policies and investments can help alleviate the risks that higher lake levels pose to shoreline communities from flooding-induced industrial pollution and infrastructure damage:

1. Great Lakes Restoration Initiative (GLRI) – Congress should fully fund GLRI for fiscal year 2023 at $400 million and increase the annual appropriation to $475 million by fiscal year 2026, as provided in the Great Lakes Restoration Initiative Act of 2019.[151] GLRI invests in work to protect shorelines, restore habitats, clean up toxic pollution, improve water quality, and more. GLRI projects support various solutions to alleviate flooding, prevent pollution from cities, and reduce agricultural runoff from farms, among other initiatives. Furthermore, each dollar spent on GLRI projects between 2010 and 2016 will produce $3.35 in additional economic activity through 2036, making it a cost-effective investment in the region.[152] Future GLRI projects should evaluate locations along the Great Lakes for potential harms from climate-driven lake level fluctuations and storm surges.

2. The Infrastructure Investment and Jobs Act (IIJA) – IIJA includes important provisions to protect the Great Lakes, including increased funding for existing programs and new ones to address wastewater, storm water threats, and clean drinking water. IIJA includes an additional $1 billion for GLRI, especially to clean up highly degraded sites, known as "Areas of Concern," including Waukegan Harbor and the Grand Calumet River highlighted in this report. The following IIJA components can support repairing and modernizing our nation's water infrastructure and can benefit the areas discussed in this report:

a. **The Clean Water Infrastructure Resiliency and Sustainability Program** can help address rising threats to clean water infrastructure from climate change.

b. **The Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM) Act** became law in January 2021 and received funding through the IIJA. This FEMA revolving loan program helps states fund projects to mitigate the risk of natural disaster. IIJA includes $500 million over five years to fund low-interest loans for local governments to help mitigate local property and infrastructure risks associated with water levels, flooding, and shoreline erosion.

3. Federal Emergency Management Agency (FEMA)'s National Flood Insurance Program should be updated to account for more extreme lake levels. FEMA is currently undergoing a new flood plain analysis survey for the Great Lakes region. The agency should incorporate the latest scientific research on the impacts of climate change and update the insurance program accordingly.

4. The Water Resource Development Act of 2020 (WRDA) created new pilot programs for studying flood risk for vulnerable, economically disadvantaged, and rural communities. It includes support for natural and nature-based solutions that prevent flooding and storm damage (including by diverting and controlling flood water), provides additional funding for harbor maintenance, and assists vulnerable communities in addressing pollution. Work on the 2022 version of WRDA in now underway; Congress should use this opportunity to increase funding for climate resilience and build in more equity to benefit communities that historically have been negatively impacted when flood control and water infrastructure projects were developed.

5. The U.S. Army Corps of Engineers' Great Lakes Coastal Resiliency Study should continue to receive Congressional funding. This long-delayed study will "create a plan identifying vulnerable coastal areas and recommending actions to bolster the coastal areas' ability to withstand, recover from and adapt to future hydrologic uncertainty with respect to the built and natural coastal environments. Recent high-water events across the Great Lakes brought about the study's need." Congress should require that the Army Corps provide an opportunity for the public to participate and provide input in a meaningful way, and the Army Corps should consider green infrastructure alternatives for reinforcing the shoreline areas and sites identified in this report.

6. The U.S. EPA Region 5 Office should increase its resources and staffing to protect the Great Lakes and its shoreline. EPA must have the policies and resources in place to support water quality monitoring and permit enforcement. In addition, EPA plays an important role in managing GLRI and other federal funding programs that support solutions to mitigate and adapt to climate change.

STATE & LOCAL RECOMMENDATIONS

Actions by state and local communities can help mitigate and adapt to the threats of higher water levels exacerbated by climate change in order to address the shoreline infrastructure challenges and pollution risks identified in this report. When possible, state and local governments should take advantage of the federal programs noted above, including applying for federal funding to address the issues highlighted in this report. Policymakers should actively work together with affected communities to identify solutions and explore "all of the water management tools in the toolbox," including:

1. Reevaluating risks of lakeshore projects: Proposed projects should be reevaluated in light of new climate conditions that could mean increased flooding on shorelines. For example, The Army Corps of Engineers has proposed to expand the Confined Disposal Facility (see page 17), a hazardous waste landfill located in the Southeast Side of Chicago along the Lake Michigan shoreline.

2. Reassessing vulnerabilities: States and municipalities should reevaluate and reduce risks from toxic sites – landfills, coal ash storage ponds and industrial facilities – along the shoreline that were not necessarily built to withstand higher water levels and flooding. Given the climate-related predictions of more extreme lake levels, cleaning up toxic sites along the lakeshore is more important than ever.

3. Updating local zoning and planning: Most communities' land use planning, zoning, and development laws and practices are outdated and based on historic lake levels instead of the increasingly more extreme Lake Michigan water levels. Communities should update their planning standards to reflect the new realities and consider innovative approaches to water management.

4. Investing in nature-based solutions: Communities have many options to strengthen shoreline resilience, including:

a. **Wetlands restoration** and other environmental engineering approaches to absorb overflow from Lake Michigan and reduce some of the pressure from higher water while also providing more wildlife habitat.

b. **Green infrastructure**, such as permeable pavers, rain gardens, green roofs, bioswales, and rain barrels, which can absorb and filter stormwater where it falls, rather than overwhelming city drainage systems and flooding streets.

5. Assessing the impacts of low water levels on marinas, water intake pipes and wildlife. when water levels are low. While most of this paper explored high water threats, extremely low water can also be damaging to shoreline infrastructure and ecosystems. Many buildings depend on the lake for industrial and commercial cooling, which would not function if intake pipes were exposed. Most importantly, leaders must ensure that drinking water intake pipes are safe under both extremely high lake water levels and low water levels.

6. Maintaining updated state water plans: Great Lakes states should create cohesive plans that incorporate the realities of climate change. Illinois is currently updating its state water plan for the first time since 1984, and is focusing on resiliency, water infrastructure assessment, and urban flooding mitigation. Michigan updated its clean water plan in 2020, with a focus on drinking water quality and access, wastewater protection, and contamination risk reduction. Indiana has not updated its water plan since 1988.[153]

Mitigating climate change: bigger picture--accelerating climate change solutions is a shared global responsibility. We must think globally, but also act locally in advancing clean energy and clean transportation policies, practices, and technologies.

Conclusion

The Great Lakes are already being impacted by climate change, which is fueling more extreme water level highs and lows. Combined with stronger winds and heavier storms, the extreme fluctuations in water levels and causing erosion, beach loss, and damage to residential areas and infrastructure all along the shore. Compounding these harms is the risk of damage to a broad range of shoreline industrial facilities that have the potential to pollute the lake if breached.

Given predictions of changing and more extreme water level fluctuations, Lake Michigan communities must reassess the risks to their shoreline infrastructure. In addition, federal, state, and local governments must actively work to mitigate the threat of climate change and protect against flooding-induced industrial pollution and infrastructure damage. Indeed, we must all work together to prepare for and adapt to new extremes, and to mitigate against worsening conditions.

The time for action is now to shape a strong, sustainable future. We're all in this together. Learn more at www.elpc.org/

Appendix 1: Methodology

INUNDATION ESTIMATES FROM THE ENHANCED BATHTUB MODEL

Water levels resulting in inundation to areas along Lake Michigan's southern shoreline were estimated using an enhanced bathtub model. This GIS-based method maintains hydrological connectivity and incorporates beach slope and surface roughness to estimate inundation extent and severity during storm-related coastal flooding events. There are shortcomings to the GIS-based methods, stemming from a disregard of dynamic variables such as seasonal waves, storm surge, and erosion, which have been shown to have a substantial impact on coastal communities. However, the results of our study are still appropriate for initial risk assessment, prioritizing management actions, education, and awareness of potential impacts. These maps are not a substitute for higher resolution, site-specific, hydrodynamic analysis, which is currently underway to update Flood Rate Insurance Maps in the Great Lakes region.

The methodology was applied to Digital Elevation Model (DEM) data prepared by the NOAA Office for Coastal Management and available through the Lake Level Viewer application. The DEMs were sourced from topobathy lidar and dredge survey data from the U.S. Army Corps of Engineers and multibeam sonar data from the National Park Service. The elevation data is provided at a fine three-meter resolution and does not incorporate changes to coastal geomorphology or protective structures since its creation.

COMPARISON WITH NOAA LAKE LEVEL VIEWER

The enhanced bathtub model used in this analysis generally produces more conservative flooding estimates than the simple bathtub approach used by NOAA in 2014. The simple bathtub model can produce disconnected areas of inundation which are less realistic than the hydrologically connected results of the enhanced bathtub model. However, given the recent trend toward high water levels as well as wave action during extreme weather events in the Great Lakes, higher future levels were applied in the present analysis than are available in the Lake Level Viewer. Lake Michigan water level and wave action trends are discussed in more detail below. The maximum level tested in the Lake Level Viewer is 584.8 feet, while the present analysis considered levels up to 589 feet.

BACKGROUND ON LAKE MICHIGAN WATER LEVELS

Great lakes water levels are complicated because of a great degree of long-term, seasonal, and short-term variability. This wide range of historic levels and regular oscillation is unlike other coastal regions where accelerating sea level rise presents a different, but more predictable, challenge for coastal managers.

Historically, long-term water levels for Lake Michigan-Huron have fluctuated within 1.5 to 2.0 feet of long-term averages near 578.5 feet International Great Lakes Datum (IGLD), 1985 on decadal timescales. Recently, however, fluctuations have accelerated and increased in amplitude. Record lows in 2013 and record highs in 2020 represent a fluctuation of nearly 6.5 feet in less than a decade.

Future long-term water level ranges are difficult to predict because climate change is altering continental-scale weather patterns, which are responsible for changes in water levels. Global climate models do not represent these weather processes in an accurate or precise enough manner to provide more clarity. Strong trends have already been identified of increasing precipitation in the Great Lakes region, and especially extreme storm events that cause local flooding. However, temperatures are also increasing, which has an opposite effect on water levels through evaporation.

Great Lakes water levels also vary seasonally; month-long averages in June-July-August are typically around one foot higher than those in January-February for Lake Michigan-Huron. Seasonal forecasting is provided by the U.S. Army Corps of Engineers Detroit office through the Monthly Bulletin of Lake Levels for the Great Lakes. Forecasting lake levels involves accurately representing overlake and overland processes of water movement including precipitation, snowpack, ice cover, streamflows, evapotranspiration

and infiltration, in combination with regulation of control structures at rivers. Generally, water level predictions are accurate to within a few centimeters for a month out, but error increases for more distant forecasts, with up to 30 cm for six-month predictions. There are also predictable patterns of statistical bias in the U.S. Army Corps forecasts: they tend to overestimate water levels during periods of low water and underestimate them during high water periods.

Local, short-term variability in water levels can be even more dramatic than long-term changes. Regular oscillations of 1.5 to 2.0 feet over the course of a single day can be observed at many monitors along Lake Michigan's shoreline (see data and visualizations available from NOAA's Tides and Currents Project). During storms, wave action, precipitation, runoff, and drainage—all mediated through coastal geomorphology and shoreline structures—combine to produce total storm surge. To predict levels of storm surge for specific sites, researchers typically employ hydrodynamic models, requiring expert skills, high-resolution data, and specialized software run on high-performance computers. Recent estimates of total storm surge for 100-year storms for the Lake Michigan shoreline, based on interpolations of fetch and historical observations, range from 3.7 to 5.2 feet. Wave energy also increases with higher lake levels, compounding the risk of flooding (Meadows et al. 1997).

ANALYZING PEAK WATER LEVEL DATA FROM LAKE MICHIGAN GAUGES

This report analyzes the effects of water levels between 584 feet and 589 feet, based on lake level trends between 2000 and 2021. Using data made available by NOAA that records water levels every six minutes at four gauges in Lake Michigan—Calumet Harbor (Chicago), IL; Holland, MI; Ludington, MI; and Milwaukee, WI—we analyzed peak water levels at each gauge between 2000 and 2021. The emphasis on peak levels (rather than mean levels) is appropriate because floods tend to be short-term upward deviations from the mean, typically lasting just a few hours. Record low water levels, such as those recorded in 2013, present problems as well, but the goal of this report is to highlight risks of high water levels and consequent flooding events. The results of the analysis are as follows.

First, at each gauge, the mean itself has steadily increased over time, including sharp increases since 2015. For example, at Calumet Harbor, the mean lake level held relatively stable at 577.6 feet between 2000–04, 577.8 feet between 2005–09, and 577.7 feet. between 2010–14. Then, for the 2015–19 period, the mean jumped to 580.3—an increase of 2.6 feet. The mean was 581.5 feet in 2020–21—a further jump of 1.2 feet. The annual average was highest in 2020, at 581.9 feet.

Second, at each gauge, peak water levels have also jumped sharply since 2015. For example, at Calumet Harbor, the lake level reached a peak of 580 feet in the 2000–04 period, 579.9 feet in 2005–09, 581.7 feet in 2010–14, 583.2 feet in 2015–19, and 583.4 feet in 2020–21. The maximum water level across gauges was recorded in Ludington, MI, at 583.5 feet.

Third, the top five peak water levels at each of the four gauges were recorded between December 2019 and October 2020.

Fourth, we studied linear projections of the peak water level up to the year 2040. The 584 feet mark lies within the 95% confidence interval at each gauge by 2030, and at Calumet Harbor in Chicago by 2022. Further, the entire range studied here (584 feet to 589 feet) lies within the 95% confidence interval at each gauge by 2030—and at Calumet Harbor in Chicago by 2025. This means, essentially, that there is a statistically significant chance of reaching peak levels of 584 feet within the next two years, and of reaching peak levels of 589 feet within the next decade.

Finally, for peak days on each gauge, we analyzed deviations from the mean water levels. These fluctuating peaks can be considered imperfect measures of wave action during extreme weather events. For example, at Calumet Harbor, the record high of 583.4 feet was recorded on April 29, 2020. On that date, the mean water level was 582.7 feet, and the maximum upward and downward deviations were each approximately 0.8 feet. The total fluctuation between maximum and minimum of 1.6 feet provides a rough estimate of wave action. The

highest upward deviation on a gauge peak day was recorded at Ludington, at 1.1 feet. The total deviation on that day (from highest to lowest level), recorded in just a 2-hour period, was 1.6 feet. The highest total deviation on a gauge peak day was approximately 1.6 feet at two other locations as well—Calumet Harbor, and Holland.

ANALYZED WATER LEVELS

In this analysis, flood risks were assessed at four water levels beginning at 178 meters (584 feet), increasing in steps of half a meter, with the highest level assessed at 179.5 meters (589 feet). The base level of 178 meters is 0.5 meters above the all-time high month-long average for Lake Michigan-Huron set in October 1986 (i.e., 177.5 meters). Accordingly, these assessments should be considered as risks during extreme storms occurring during high water periods.

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Appendix 2: Endnotes

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